5-2019

Interdevice Reliability of A-Mode Ultrasound to Measure Body Composition

Megan Bigler
Utah State University

INTERDEVICE RELIABILITY OF A-MODE ULTRASOUND TO MEASURE BODY COMPOSITION

by

Megan Bigler, ATC-L

A plan B research project submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Health and Human Movement- Sports Medicine

_____	_____
Dale Wagner, Ph.D.	Brennan Thompson, Ph.D.
Major Professor	Committee Member

_____
Edward Heath, Ph.D.
Committee Member

UTAH STATE UNIVERSITY

Logan, Utah

2019

Summary

A-mode ultrasound is a noninvasive and rapid method for measuring subcutaneous fat thickness and estimating body fat percentage (%BF). The validity and reliability of the BodyMetrix BX2000 A-mode ultrasound has been reported; however, the purpose of this study was to compare results from two machines to determine interdevice reliability. Ultrasound measures were repeated with two BX2000 machines at 10 body sites (chest, biceps, triceps, scapula, lower back, hip, waist, thigh, calf, axilla) on 42 males of varying age and leanness (age: 28.6 ± 11.9 y, BMI: 25.4 ± 4.6 kg/m^2). The intraclass correlation coefficients ranged from 0.939 to 0.998 with standard errors of measurement from 0.31 to 0.58 mm of fat thickness. The only statistically significant difference ($p < 0.001$) between devices was at the chest (0.33 mm) and scapula (0.37 mm). However, there was no difference between machines in the estimation of %BF (0.34%BF; $p = 0.09$). The interdevice reliability is similar to the previously reported test-retest reliability with no clinical significance between the two machines.

Keywords: subcutaneous fat, body fat, BodyMetrix, BodyView Professional, variability

Introduction

The use of ultrasound as a diagnostic tool to measure subcutaneous fat has recently increased in popularity. This method is fast, cost-effective, portable, and easy to use. A-mode (amplitude mode) ultrasound uses sound waves to penetrate the skin for a graphical representation of body composition. The sound waves are reflected at each tissue interface with greater amplitudes at the subcutaneous fat-muscle and muscle-bone junctions. The spikes or peaks on the graph correspond to the thickness of subcutaneous fat by depth in millimeters. For a more complete explanation of this technology, see the review by Wagner (2013).

A commercial A-mode ultrasound device commonly used for measurement of body composition is the BodyMetrix BX2000 (IntelaMetrix, Inc., Livermore, CA, USA). In a recent study (Wagner *et al*., 2018), the validity of the BodyMetrix device for measuring subcutaneous fat thickness was determined by comparing site-specific A-mode measures to a high-resolution B-mode (brightness mode) ultrasound device. Both ultrasound measurements were compared to the dissected subcutaneous fat thickness of cadavers. There were no significant differences between A-mode and B-mode ($p > 0.05$) with reported mean differences of < 0.7 mm at various measurement sites, and the intraclass correlation coefficient (ICC) was > 0.90 for almost all sites. When compared to manual measurements of fat thicknesses of the dissected cadavers, both A-mode and B-mode ultrasound were similarly accurate.

Test-retest, day-to-day, and interrater reliability of the BodyMetrix BX2000 have also been evaluated (Loenneke *et al*., 2014; Smith-Ryan *et al*., 2014; Wagner *et al*., 2016; Wagner & Teramoto, 2019). Test-retest reliability for the estimate of body fat percentage (%BF) obtained from the BodyMetrix BX2000 was reported to be excellent with an ICC of 0.996 (Wagner *et al*., 2016). Similarly, the day-to-day reliability was nearly as good with ICCs ranging from 0.935 to

0.980 (Loenneke et al., 2014; Smith-Ryan *et al*., 2014). Additionally, the interrater reliability was excellent (ICC = 0.987) for both experienced technicians (Wagner *et al*., 2016) and novice examiners (ICC = 0.969 to 0.990) (Wagner & Teramoto, 2019). Furthermore, the interrater reliability for this A-mode ultrasound device (ICC = 0.832 to 0.990) is superior to the interrater reliability for the skinfold method (ICC = 0.693 to 0.955) for measuring subcutaneous fat thickness at various measurement sites (Wagner & Teramoto, 2019).

Despite excellent ratings for test-retest, day-to-day, and interrater reliability, the interdevice reliability is unknown. The interdevice reliability is the next necessary step in determining the overall usefulness of A-mode ultrasound as a method of measuring body fat. This knowledge will increase the acceptance of A-mode ultrasound for intersite and multicenter body composition testing. The purpose of this study was to evaluate the interdevice reliability of A-mode ultrasound by comparing site specific subcutaneous fat estimates and %BF estimates from two BodyMetrix BX2000 machines.

Methods

Participants

This study included 42 male participants, ranging from 18 to 57 years of age. The participants represented a distribution of body types: 16 elite, 18 athletic, and 8 non-athletic. The BodyMetrix BX2000 requires input of one of these three body types to increase the accuracy of their site-specific graphical representation. The associated software (BodyView Professional) defines these body types as; elite being those with low body fat, exercise regularly, generally good muscle definition, and including those with “six-pack” abdominal muscles; non-athletic are individuals that are clearly overweight or obese; and the athletic category includes the rest of the population.

The study was approved by Utah State University's Institutional Review Board (protocol #9696). Upon arrival on testing day, participants signed a written informed consent that detailed the procedures, benefits, and risks of the study before any measurements were taken.

Protocol

Upon arrival at the lab, each participant was asked to empty their bladders before testing began. Height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively. Height was measured with a wall-mounted stadiometer (Seca 216, Seca Corp., Ontario, CA), and weight was measured with a digital scale (Seca 869, Seca Corp., Ontario, CA). All measurements were taken with the participant wearing only compression shorts. Next, date of birth was obtained to determine age, and body type as defined above was entered into the BodyView Professional software.

Each participant was measured and marked with a surgical marker at each of the seven Jackson and Pollock (1978) skinfold sites (chest, scapula, axilla, triceps, waist, hip, and thigh) as well as the lower back, biceps, and medial calf. These three additional measurement sites were used because they are sites in other %BF equations within the BodyView Professional software. All 10 sites were marked to facilitate accurate placement of the ultrasound transducer head for both devices. Site-point ultrasound measurements were taken with the participant standing, according to the manufacturer's instructions as detailed by Wagner (2013).

The participants were measured at all 10 sites with device 1, and then measurements were repeated with device 2. The BodyView software requires multiple measurements at each site to obtain a site-specific fat thickness; thus, 3-5 measurements per site were used to produce an averaged site-specific measurement for each device. The same technician took all measurements with both devices.

Statistical Analyses

Data were analyzed using SPSS version 25.0 (IBM, Inc., Chicago, IL, USA). Means and standard deviations were calculated for all variables. Paired t-tests with a Bonferroni adjustment were done to determine if there was a significant difference between the two ultrasound devices at each of the 10 sites as well as for the overall estimated %BF. With 10 paired t-tests the significant p-value became 0.005. The BodyView software uses a proprietary formula to convert the ultrasound fat thicknesses into a %BF estimation using the measurement sites of common skinfold prediction equations. The BodyMetrix conversion of the 7-site Jackson and Pollock equation (1978) was used to estimate %BF. Interdevice reliability for each of the 10 measurement sites was assessed with a single measures intraclass correlation coefficient (ICC) with absolute agreement. Additionally, standard error of measurement (SEM) was calculated [SEM = SD x $\sqrt{}$(1-ICC)]. The standard deviation used for SEM calculation was the combined standard deviations of the two ultrasound devices.

Results

The sample varied in age (28.6 ± 11.9 y), height (182.4 ± 7.6 cm), weight (84.5 ± 16.9 kg), and body mass index (25.4 ± 4.6 kg/m^2). During preliminary screening, participant 5 was determined to be a statistical outlier (> 3 SD) for the chest, hip, and axilla measurements. Consequently, this participant was removed from the site-specific analyses for these three sites but remained in the sample for the other sites and the overall %BF estimation. Interdevice reliability results are presented in Table 1. The ICCs were excellent for all 10 sites, ranging from 0.939 to 0.998. Additionally, the SEM were small, ranging from 0.31 mm to 0.58 mm.

The two ultrasound devices differed significantly ($p < 0.001$) in the measured fat thickness at the chest and scapula, differing by a mean of 0.33 mm and 0.37 mm, respectively.

There was also a mean difference of 0.30 mm at the axilla ($p = 0.013$), but this was not statistically significant after the Bonferroni adjustment. Despite these site differences, the difference in %BF between ultrasound 1 and ultrasound 2 was only 0.34 ± 1.24%BF and not statistically significant ($p = 0.09$).

Discussion

This research represents the first interdevice reliability study for the BodyMetrix BX2000 A-mode ultrasound. The high ICCs and low SEMs at each measurement site indicate excellent agreement between the two machines. Furthermore, the ICCs for interdevice reliability were similar to ICCs reported for test-retest reliability (Loenneke *et al*., 2014; Smith-Ryan *et al*., 2014; Wagner *et al*., 2016). Although there was a statistically significant mean difference in fat thicknesses between devices at the chest and scapula, these differences were very small (< 0.4 mm), resulting in no meaningful clinical significance. For example, the difference in %BF estimates between these two machines was only 0.34% despite the "statistically significant" differences in fat thickness at the chest and scapula.

An outlier was identified at the chest, hip, and axilla sites and was removed from statistical analyses specific to these sites. This outlier happened to be the subject with the largest %BF. In a study of A-mode ultrasound to measure body composition of obese and overweight individuals, Smith-Ryan *et al*. (2014) reported excellent day-to-day reliability, suggesting that the reliability of the machine was not influenced by high %BF. One limitation of the current study was that only 19% of our sample were in the "non-athlete" BodyMetrix body type classification. More research may be needed on obese individuals to determine if the outlier identified in this study is an aberration or if obese individuals are subject to machine or technician error.

Both devices used were BodyMetrix BX2000 A-mode ultrasound machines. These devices were the same model from the same manufacturer, yet one machine was several years older than the other. Despite the age difference between the devices, the interdevice reliability was excellent, suggesting that results from older devices are still comparable to newer machines.

Interdevice reliability is an important component in determining the overall usefulness of a measurement tool. High interdevice reliability gives greater confidence for comparing results between labs or testing centers. Other body composition assessment tools have undergone interdevice reliability testing. For example, both Collins *et al.* (2004) and Ball (2005) conducted interdevice reliability studies on the Bod Pod. The Collins *et al*. group performed a multi-site comparison, while Ball evaluated the reliability of two Bod Pods in the same laboratory. No clinically significant differences in the estimation of %BF were found in these interdevice reliability studies, and these studies helped to further solidify the Bod Pod as a viable assessment tool. Similar to the BodPod studies, this research yielded strong correlation and agreement between the A-mode ultrasound machines.

It is important to note that there are several A-mode ultrasound machines from various manufacturers commercially available for body composition measurement. This study was limited to the BodyMetrix BX2000 device which operated at a fixed frequency of 2.5 mHz. Other devices may operate at different frequencies or with different software algorithms. Thus, while our research suggests that the results from various clinics or laboratory settings using the BodyMetrix BX2000 can be compared, we do not recommend comparing the results from different A-mode ultrasound manufactures. In conclusion, there was no clinically significant difference between the two BodyMetrix BX2000 A-mode ultrasound machines. The interdevice

reliability was high, and any variability between the two machines had minimal effect on the estimation of %BF.

Acknowledgements

This study was conducted without external funding.

Conflicts of Interest

The authors have no conflict of interest.

References

Ball SD. Interdevice variability in percent fat estimates using the BOD POD. *Eur J Clin Nutr* (2005); **59**, 996-1001.

Collins AL, Saunders S, McCarthy HD, Williams JE, Fuller NJ. Within- and between-laboratory precision in the measurement of body volume using air displacement plethysmography and its effect on body composition assessment. *Int J Obes Relat Metab Disord* (2004); **28**, 80–90.

Jackson AS, Pollock ML. Generalized equations for predicting body density of men. *Br J Nutr* (1978); **40**: 497-504.

Loenneke JP, Barnes JT, Wagganer JD, Wilson JM, Lowery RP, Green CE, Pujol TJ. Validity and reliability of an ultrasound system for estimating adipose tissue. *Clin Physiol Funct Imaging* (2014); **34**: 159-162.

Smith-Ryan AE, Fultz SN, Melvin MN, Wingfield HL, Woessner MN. Reproducibility and validity of A-mode ultrasound for body composition measurement and classification in overweight and obese men and women. *PLoS ONE* (2014); **9**: e91750.

Wagner DR. Ultrasound as a tool to assess body fat. *J Obes* (2013); 280713.

Wagner DR, Cain DL, Clark NW. Validity and reliability of a-mode ultrasound for body composition assessment of NCAA Division I athletes. *PLoS ONE* (2016); **11**: e0153146.

Wagner DR, Thompson BJ, Anderson DA, Schwartz S. A-mode and B-mode ultrasound measurement of fat thickness: a cadaver validation study. *Eur J Clin Nutr* (2018); epub ahead of print: doi.org/10.1038/s41430-018-0085-2.

Wagner DR, Teramoto M. Interrater reliability of novice examiners using A-mode ultrasound and skinfolds to measure subcutaneous body fat. *Meas Phys Educ Exerc Sci* (2019); in press.